The effect of ramp provision on the accessibility of the litter in single and multi-tier laying hen housing

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Abstract

Level changes in commercial laying hen loose-housing systems may be physically difficult for birds to negotiate, preventing or limiting access to resources such as the litter area and the outdoor range, and potentially increasing injury risk. The aim of this research was to investigate bird behaviour at an important level change (traversing between the raised slats/first tier and the litter), and whether it was affected by ramp provision or system. Birds were either observed at the edge of a single-tier with a full width ramp (ST-R), or at a section of tier edge without ramp in multi-tier systems (MT-NR) or in single-tier systems (ST-NR), both equipped with no ramps or only intermittent ramps throughout. Compared with single-tier systems, a greater proportion of birds that showed an initial orientation towards the litter moved away without traversing in the MT-NR group ($p<0.05$). Traversing birds in group ST-R showed reduced incidences of behaviours indicative of hesitancy/difficulty. The behaviours that occurred significantly less frequently in group ST-R compared with both groups MT-NR and ST-NR were crouching ($p<0.01$), multiple crouches ($p<0.01$), pacing ($p<0.05$) and stepping on the spot ($p<0.01$). Multiple head orientations were lower in ST-R compared with ST-NR ($p<0.05$). We conclude that the provision of a full-width ramp between the raised slatted area in single-tier systems or first tier in multi-tier systems could improve bird welfare by increasing the ease of access to important resources.

Keywords:

Laying hens; Welfare; Behaviour; Single-tier; Multi-tier; Ramp use

1. Introduction

Hen welfare is of increasing interest to consumers, and legislation to reduce the number of birds kept in restrictive cage systems can now be found worldwide. For example, following the ban on conventional cages for laying hens in the EU in 2012 (Council Directive 1999/74/EC) 49% of UK egg production now comes from loose-housing systems (DEFRA 2016).

Commercial loose-house systems for laying hens vary widely in design but two fundamental types can be distinguished, both with littered areas at ground level. Single-tier systems have one raised slatted area on which the birds can access nestboxes, food and water. In multi-tier systems (also known as aviaries) the slatted areas are usually up to three tiers high with resources available on each of these different levels. Either system may have additional outdoor access (free-range) by providing popholes to the range, which are most commonly accessed via the litter areas. It is therefore essential in all loose-housing systems that the birds are able to traverse level changes in the house effectively if they are to reach all of the available resources. In particular, the slats (or first tier) to litter level change must be negotiated by the hens if they shall have access to foraging material and often the outdoor range.

The importance of access to these resources for bird welfare is well-documented. Feather pecking is a serious welfare issue particularly in loose-housed laying hens and access to a suitable foraging substrate is of great importance in its prevention (Nicol et al. 2013). Additionally, dustbathing can be considered a behavioural need (Weeks and Nicol 2006) and requires a fine, friable substrate for its full performance (Van Liere et al. 1997). To enhance welfare, various enrichment items and resources are frequently provided to commercial laying hens in both the indoor environment and outdoors (if free-range). The outdoor area can provide the opportunity for birds to express their full behavioural repertoire and has been shown to be beneficial to welfare through a reduced risk of feather pecking (Nicol et al. 2003).

Access to these important resources may be compromised if level changes in the house act as barriers that are physically difficult for birds to negotiate, inhibiting bird movement. If hens find the level change difficult, they may either injure themselves trying to traverse or choose to avoid traversing the level altogether, resulting in reduced behavioural opportunity through a restricted environment. Certainly, range use is highly variable and often low on commercial farms, with inhibited bird movement within the house highlighted as a potential causal factor (Pettersson et al. 2016).

Although the behaviour of birds traversing perches in experimental setups has been described (e.g. Taylor et al. 2003, Lambe et al. 1997) there is almost no information regarding the ability of birds to move between the slats, tiers and litter areas of a commercial single or multi-tier housing unit. Recent work on a lone multi-tier unit has shown that hen movement occurs in all areas of the system but whether all birds accessed all areas was unclear (Campbell et al. 2016a). Collisions and poor landings may occur, potentially leading to injury. Recent work found that 9.1% and 21% of observed flights failed in two multi-tier flocks (Campbell et al. 2016b). Previous research has shown that the risk of injury increases when birds have to jump a distance greater than 80cm vertically or jump an angle between 45 and 90° (for a review see EFSA AHAW Panel, 2015). The shortest transition height to the litter from multi-tiers is similar to that in single-tier houses, but multi-tier systems may be more hazardous as birds can get up very high and are therefore more likely to fall from a height. Keel bone fractures sustained during the lay cycle are highly prevalent in loose-housed hens (Wilkins et al. 2004, 2011) and more so in multi-tier systems (Rodenburg et al. 2006, Käppeli et al. 2011).

Some producers provide ramps for the birds between the slats and litter in single-tier systems and the first tier and litter in multi-tier systems with the intention of aiding them to negotiate this level change. Providing ramps at different levels in multi-tier set-ups has been associated with reduced falls, collisions and keel bone fractures and greater controlled movement (Stratmann et al. 2015). These ramps or ladders may be intermittent, narrow structures along the edge of the slats or in some single-tier systems, comprise a full width ramp along the entire border of the slatted area with the litter (Fig 1).

Movement in commercial houses is a research area of growing interest and importance, particularly in multi-tier systems (Stratmann et al. 2015, Campbell et al. 2016a,b). Stratmann et al. (2015)'s research was based on experimental pens within a commercial house and recent work by Campbell et al. (2016a,b) studied two flocks in one commercial house. Small scale studies cannot always be widely applied due to the variety of housing designs seen commercially. It is therefore important to study multiple houses and there remains a lack of research on bird movement on this scale. This study aimed to apply existing knowledge of bird movement and flight abilities to the commercial setting with a specific focus on behaviour immediately prior to changing levels. We studied the effects of house design, specifically single vs multi-tier housing, and ramp vs no ramp provision, on (i) the likelihood of birds completing a downward traverse to the litter area after initiation of a traverse, (ii) their behaviour prior to a traverse and (iii) the time taken to reach the litter after initiation of a traverse.

2. Methods

In total 16 commercial, free-range laying hen houses were studied when the birds were approximately 40 weeks of age. Twelve of the houses were visited on two occasions (at 40 weeks in different flock cycles) as part of a wider research project. All flocks were brown genotypes with an average flock size of 13,044 (see table 1). Stocking densities were between 8 and 9 birds/m^2 in line with UK legislation. See table 1 for a summary of house and flock information. The four multi-tier flocks were reared in multi-tier systems and all others in single-tier systems.

This study focused on the behaviour of birds as they approached the edge of the slats (or first tier) and oriented into a position where they could move down from the slatted area (or first tier) onto the litter area. The 16 houses were split into three groups based on their design. Group ST-R (n=7) consisted of single-tier houses with a full width ramp across the entire slat-litter level change (as in Fig 1). These ramps were made of plastic slats. Group MT-NR (n=4) comprised multi-tier houses with intermittent or no ramps between the first tier and the litter. Group ST-NR (n=5) consisted of single-tier houses with intermittent or no ramps between the slats and litter.

2.1. Behavioural observations

All observations were performed by the same observer. In each house three or four 2m sections along the edge of the slats (or first tier) were randomly selected (see Fig 1). Where intermittent ramps were present, a section with no ramp was chosen.

For each section, focal birds within this area were studied for 10 minutes. It was not possible to record all birds that moved down to the litter within the 10 minutes as multiple birds moved at once on some occasions. The number of focal birds studied therefore varied, although a limit of 10 were observed per section.

A focal bird was selected for observation if it entered the 2m section and was facing the litter when a direct head orientation towards the litter was observed. The time from this head orientation until birds reached the ground (‘Time to litter’), or moved away (‘Time to move away’) was recorded using a stopwatch. A bird was considered to have moved away if it orientated away from the litter and showed no further intention behaviours for 10 seconds (see table 2).

The occurrences of behaviours preceding each traverse to the litter or move away were tallied. See table 2 for an ethogram of the behaviours recorded in this study. The behaviours ‘crouch’ and ‘head orientation’ were precursors to a jump so two additional variables were calculated in order to pick up on birds that crouched or head orientated without jumping – the percentage of birds that performed 2 or more head orientations: “multiple head orientations”, and the percentage that performed 2 or more crouches: “multiple crouches”. For the ST-R group it was also noted whether the bird jumped/flew or walked down the ramp.

2.2. Analysis

All data were analysed using SPSS 23.

Data from focal birds from each section were combined and percentages of individuals that performed each behaviour were calculated for each house. Mean times to litter or times to move away per house were also calculated from all observed individuals.

As 12 houses were visited twice (two different flock cycles) the percentages for each behaviour and time to litter for these two visits were averaged to create a single point for each house. The remaining 4 houses were only visited on one occasion so data from this visit only were analysed. House, rather than flock, was used as the independent statistical unit because the substantial differences in house design were considered likely to have the greatest effect on bird movement. After checking for the effect of house design on whether birds moved away or not, the data from birds that traversed was analysed separately from the data from birds that moved away.

Standardised residuals of each variable were first checked for normality using a Shapiro-Wilk test and P-P plots, with logarithmic or square root transformations performed where possible on variables with non-normal residuals.

Data were analysed using one-way ANOVAs with house design group as a factor, and post-hoc Tukey HSD tests. Levenes test was used to check homogeneity of variances and if homogeneity was not found a non-parametric test was used. Variables that could not be transformed to achieve normally distributed residuals were also analysed using the non-parametric equivalent, the Kruskall-Wallis test. In order to detect group differences following a significant Kruskall-Wallis test, individual Mann-Whitney U pairwise comparisons were performed and the significance level corrected using the Bonferroni correction to 0.017 for these tests.

A one-way ANOVA was also performed to compare house systems regarding height of the first tier. Pearson and Spearman correlations were performed on tier-height and behaviour data.

3. Results

3.1. Effect of ramp group on likelihood of moving away

A significant effect of ramp group was found on the likelihood of a bird moving away instead of traversing to the litter ($F(2,13)=8.949$, $p=0.004$). Post hoc testing revealed that a higher percentage of birds moved away in group MT-NR (26.12%) than both group ST-R (9.57%) and group ST-NR (11.72%) ($p<0.05$).

3.2. Effect of ramp group on behaviour – traversing birds only

House design had a significant effect on time to litter ($F(2,13)=6.351$, $p=0.012$) and the percentage of birds performing multiple head orientations ($F(2,13)=3.827$, $p=0.049$). Post-hoc testing revealed that providing full-width ramps in single-tier systems (ST-R) reduced the percentage of birds performing multiple head orientations ($p<0.05$) compared with the single-tier non-ramp group (ST-NR) group. Birds from group ST-R took significantly longer to reach the litter than birds from group MT-NR ($p<0.05$).

House design significantly influenced pacing ($F(2,13)=11.614$, $p=0.001$) and stepping behaviours ($\chi^2= 11.639$, $p=0.003$). A significantly lower percentage of birds paced ($p<0.05$) or stepped ($p<0.01$) in group ST-R compared to both groups MT-NR and ST-NR.

The presence of a full-width ramp had a significant effect on the percentage of birds that crouched at least once ($F= 100.187$, $p<0.001$) and on the percentage that performed multiple crouches ($F= 25.912$, $p<0.001$). Decreased crouching behaviour was seen when a full-width ramp was present (ST-R) compared with both non-ramp groups (MT-NR and ST-NR) (<0.01).

All traversing birds in groups MT-NR and ST-NR jumped/flew to the litter. Of the 7 houses in group ST-R, in only 3 were any focal birds observed jumping instead of walking down the ramp. House 2 had 19.57% that jumped, 5.56% jumped in house 7 and 1.79% jumped in house 8. Therefore the majority of birds used the ramp to walk the entire way to the litter, likely resulting in the overall slower descent seen in this study in the ST-R group.

House design significantly affected the likelihood of crash landings ($\chi^2= 10.253$, $p=0.006$). Crash landings were only observed in three houses, all of which were in the multi-tier group.

See table 3 for means and standard deviations of each group.

3.3. Effect of tier height on behaviour – traversing birds only

Mean tier height was not significantly different between treatment groups ($F=2.829$, $p=0.096$). To check for the potential effect of tier height on the results across all houses in the study, bivariate correlations between height and all behaviours revealed no significant correlations. This was repeated with group ST-R excluded (as a full width ramp may have reduced the importance of tier height) and again no significant effects of tier height on behaviour were seen.

3.4. Effect of ramp group on behaviour – birds that moved away only

When analysing the birds that moved away without traversing, ramp group had a significant effect on the percentage of birds that paced (χ^2= 6.471, p=0.039) and on those that performed multiple crouches (χ^2= 6.138, p=0.046). In multi-tier houses (group MT-NR) a significantly greater percentage of birds paced or crouched multiple times ($p<0.05$) than those in single-tier houses with full length ramps (ST-R). Due to lower focal bird numbers contributing to the mean in the dataset of birds that moved away the effect of tier-height was not investigated as confidence in the dataset was not high enough for a correlation analysis.

4. Discussion

A bird that has no difficulty negotiating a level change (without a ramp) would be expected to approach, crouch and jump in quick succession and land well. However, this is not always the case and behaviours indicative of hesitancy were chosen for observation in this study. Crouching as if to take-off but subsequently hesitating has been described as an 'intention movement' (Lambe et al. 1997) and sidestepping may also indicate intention to attempt a jump but difficulty doing so (Lambe et al. 1997). Some birds may walk away after showing these behaviours instead of jumping. Poor landings can indicate a jump that is too steep, too long, or obstructed (Scott et al. 1997, Moinard et al. 2005). Gakel calls (Zimmerman et al. 2000) are associated with frustration but in this study it was not possible to record vocalisations owing to high levels of bird noise in the houses.

4.1. Effect of house design on likelihood of moving away

More than twice the percentage of birds moved away without traversing the level-change in multi-tier houses compared with single-tier full width ramp houses. It is difficult to explain this effect without information about where the birds went after moving away from the tier edge. Whether birds were moving away in order to find a better location to jump (e.g. an intermittent ramp) or whether they were giving up altogether is not clear although both possibilities have an effect on welfare. If the birds were moving to find a better location they would be wasting time and energy, and potentially disrupting other birds. Crowding around intermittent ramps may also occur if birds are choosing not to traverse in non-ramp areas, potentially increasing the risk of a fall as a result of being pushed by conspecifics as was observed in aviaries by Stratmann et al. (2015). If the hens are actually giving up altogether and deciding against moving to the litter they will have reduced welfare through lack of access to important resources. This may be of additional welfare concern in multi-tier systems as hesitancy at the first-tier to litter level-change may also mean that birds struggle similarly with tier to tier changes.

4.2. Effect of ramp group on behaviour – traversing birds only

As crouching was seen in over 95% of observations where birds had to jump (MT-NR and ST-NR) and 100% of observations in group ST-R where birds jumped instead of walking down the ramp, we can conclude that a crouch was nearly always a precursor to a jump. It is therefore unsurprising that significantly fewer birds showed at least one crouch (30%) in the full width ramp group than the other two groups. Most birds in the ST-R group simply walked down the ramp, so they did not need to jump.

The percentage of birds exhibiting multiple crouches, pacing or stepping on the spot was significantly lower in the full ramp group than in both non-ramp groups. In single-tier houses, fewer birds performed multiple head orientations in the full ramp group than in the non-ramp group. These four behaviours are likely indicative of difficulty traversing the level-change. Pacing has been used as an indicator of frustration during thwarted access to resources (Duncan and Wood Gush 1972) although this is a more stereotyped behaviour and develops as a result of long-term frustration. In the current study it is not clear whether long-term frustration was being observed or simply that the pacing behaviour reflected the indecision of the birds, and dissatisfaction with potential landing spots. Ramps allowed birds to change their 'landing' spot while walking down and this may be why less pacing was seen in the ramp group. Similarly, stepping may have indicated intention to jump but a need for the bird to adjust their position repeatedly in preparation for the jump. This movement was similar to the 'sidestepping' recorded by Lambe et al. (1997) and likely indicates a similar intention. As a head orientation and crouch were typical precursors to a jump, the occurrence of multiple incidences of these behaviours suggests that, in some birds, intentions can be over-ridden, sometimes repeatedly, before a final decision to jump is made and executed.

Whether a bird landed well or crashed into the litter/another bird was also recorded and found to be significantly affected by house design, with all incidences occurring in multi-tier houses. This is in line with existing literature showing that keel fractures are higher in multi-tier systems (Käppeli et al. 2011). Nasr et al. (2012a) found that birds with fractures took longer to jump between perches suggesting poorer mobility. Crashes and fractures could therefore affect future mobility and therefore welfare. The fact that so few crashes were seen is certainly positive for bird welfare. However, it is possible that birds were deciding to move away instead of completing the level-change to avoid potential crashes. If this was the case, birds were having to choose between access to resources and the risk of injury, not a situation that favours good welfare.

4.3. Effect of tier height on behaviour – traversing birds only

A range of tier heights was measured but this did not appear to have affected the results as mean heights for each ramp group were not significantly different and correlations indicated no relationship between tier height and the behaviours recorded. It therefore appears that the presence or absence of a ramp is more important at the point of level-change, than the height of tier within the range observed here. Producers may choose to use none or intermittent ramps instead of full-width ramps because the height difference between the slats and litter in their hen house is smaller than average (e.g. <60cm) and they believe that the birds do not need the full-width ramp. These results suggest that this may be an incorrect assumption. In addition, full width ramps take up floor space and minimum litter space allowances mean that ramps are not practical in some pre-existing house set ups.

4.4. Effect of ramp group on behaviour – birds that moved away only

More of the focal birds that did not traverse were seen to crouch multiple times or pace in the multi-tier group than the full ramp group. This supports the result from the traversing birds - that the presence of a full ramp reduces some behaviours indicative of hesitancy at a level change. Average percentages of the behaviours recorded for the MT-NR and ST-NR groups were very similar (table 3) and the lack of significant results when comparing with the ST-NR group is likely due to the increased variability of the data. It should also be noted that as the percentages calculated for this group were based on a lower number of birds than for those calculated for traversing birds, confidence in these results is slightly lower.

4.5. Limitations

There are some limitations to this study. As birds were observed in non-ramp areas only of houses with intermittent ramps it is not possible to look at whether greater numbers of birds were seen using intermittent ramps than non-ramp areas, or whether the behaviour of the birds was different on these ramps. This would be a valuable point for further study. Additionally, the results may only be applicable to brown genotypes as genotype is likely to have an effect on ability to jump, manoeuvre and move throughout the house. Brown birds are nearly always used in loose-housed systems in the UK and may struggle with level changes more than white birds owing to their heavier build (Scholz et al. 2014). Although, relatively few birds were observed in each house, we expect good repeatability if further birds were studied. The flocks studied came from a variety of rearing farms and we were unable to control for this. Rearing environment can affect mobility in later life (Gunnarsson et al. 2000) but as all birds were reared in a set-up that matched their adult environment (single vs multi-tier) the results are unlikely to have been confounded by this.

5. Conclusions

This study has indicated that some laying hens in commercial housing show behaviour indicative of reluctance to move down onto the litter and that this is influenced by both ramp presence and house design.

More than double the percentage of birds moved away without accessing the litter in multi-tier houses than single-tier houses. Far fewer hens showed behaviours indicative of difficulty moving down to the litter when a full width ramp was provided between the slats and the litter.

The results of this study suggest that providing full-width ramps could improve hen welfare by enabling hens to access the litter more readily. Even when intermittent ramps were provided (as in most houses of groups MT-NR and ST-NR) birds still attempted and struggled to negotiate level changes in areas without a ramp. The addition of a full-width ramp to a commercial single-tier hen house is relatively easy and may benefit welfare by providing easier bird movement and access to resources. Easy movement to the litter area may also reduce crowding on the slats. Where adding a full-width ramp is difficult or impossible (e.g. some multi-tier systems) further research into alternative ramp designs would be valuable.

Acknowledgements

We gratefully acknowledge funding by Noble Foods. The authors would also like to thank all 16 farmers who kindly allowed us to carry out this research on their farms.

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Table 1: Summary information for each house used in the study (House design groups: Single-tier with full width ramp (ST-R), multi-tier with no or intermittent ramps (MT-NR) and single-tier with no or intermittent ramps (ST-NR)).

House	**Size**	**No. flocks**	**Genotype(s)**	**House design group**	**Intermittent ramps present?**	**Height of first tier/slats (cm)**	**Ramp angle (degrees)**
1	16,000	2	Novogen Brown	MT-NR	Yes, ladders (45cm)	70	N/A
2	11,700	2	Novogen Brown	ST-R	N/A	100	56
3	6,950	2	Lohmann Brown, Novogen Brown	ST-R	N/A	90	46
4	16,000	2	Lohmann Brown	MT-NR	Yes, flat ramps (230cm)	88	N/A
5	15,848	2	Novogen Brown	ST-R	N/A	90	49
6	6,000	1	Hyline	ST-NR	Yes, ladders (350cm)	65	N/A
7	16,032	2	ISA Warren, Bovan Brown	ST-R	N/A	90	49
8	15,030	2	Lohmann Brown, Novogen Brown	ST-R	N/A	85	47
9	12,525	2	Lohmann Brown	ST-R	N/A	75	39
10	16,032	2	Lohmann Brown, ISA Brown	ST-NR	Yes, ladders (300cm)	95	N/A
11	16,032	2	Shaver	MT-NR	Yes, ladders and integrated slatted step (150cm)	75	N/A
12	12,024	1	Novogen Brown	ST-NR	No	32	N/A
13	16,032	2	Hyline, Lohmann Brown	MT-NR	Yes, ladders and integrated slatted step (150cm)	85	N/A
14	16,000	2	Lohmann Brown	ST-R	N/A	90	49
15	5,760	1	Shaver	ST-NR	Yes, ladders (300cm)	80	N/A
16	10,800	1	Bovan Brown	ST-NR	No	70	N/A

Table 2: Ethogram of observed behaviours in focal birds.

Behaviour name	**Description**
Head orientation	The bird lowers its head and neck and looks at the litter.
Crouch	The bird lowers the body while the head is orientated towards the litter.
Pace	The bird walks along the edge of the slats. A pace must be followed by a head orientation/crouch/step within 10 seconds or it is deemed a ‘move away’.
Step	While facing out towards the litter, the bird raises its feet individually and places them back down in a similar location as if adjusting its position.
Move away	The bird orientates its body away from the litter, moves away from the edge of the slats or moves along the edge of the slats without showing further intention behaviours for 10 seconds.

Table 3: Average means and standard deviations for traversing and moved away birds in each ramp group. Significant relationships between variables are marked with superscript letters.

	TRAVERSING BIRDS			MOVED AWAY BIRDS		
GROUP	**ST-R (n=7)**	**MT-NR (n=4)**	**ST-NR (n=5)**	**ST-R (n=7)**	**MT-NR (n=4)**	**ST-NR (n=5)**
Tier height (cm)	89 (±7)	80 (±8)	68 (±23)	89 (±7)	80 (±8)	68 (±23)
Total number of focal birds	345	176	150	39	60	20
Average number of focal birds per house (1-2 flocks)	49(±2)	44(±3)	30(±2)	6(±1)	15(±2)	4(±1)
Time to litter/move away (s)	10.6 (±3.8)[a]	4.1 (±0.8)	7.5 (±5.6)[b]	20.5 (±5.8)	16.4 (±4.5)	22.2 (±15.0)
Multiple head orientations (%)	11.81 (±8.35)[a]	17.15 (±4.56)[b]	25.32 (±10.30)	35.60 (±24.88)	30.21 (±16.42)	29.17 (±44.29)
Crouch (%)	29.65 (±12.86)[a]	97.87 (±2.46)[b]	96.55 (±6.19)[b]	28.81 (±15.17)	36.79 (±16.74)	48.00 (±29.80)
Multiple crouches (%)	0.31 (±0.82)[a]	5.99 (±3.03)[b]	13.29 (±8.64)[b]	0.00 (±0.00)[a]	5.58 (±6.11)[b]	5.00 (±11.18)
Pace (%)	1.62 (±2.63)[a]	12.59 (±6.43)[b]	17.28 (±8.19)[b]	1.43 (±3.78)[a]	10.96 (±4.33)[b]	20.00 (±44.72)
Step (%)	0.96 (±1.74)[a]	12.36 (±8.13)[b]	13.91 (±5.07)[b]	0.89 (±2.36)	6.52 (±8.09)	5.00 (±11.18)
Crash landings (%)	0.00 (±0.00)[b]	2.94% (±2.52)[a]	0.00 (±0.00)[b]	N/A	N/A	N/A

Figure 1: Photograph of a single-tier system with full width ramp (ramp angle: 46°). An example section for behavioural observation has been marked on the image.